3D-numerical modelling of suspended sediment transport in the Passaúna Reservoir

Modelling sediment deposition; volumes and patterns

Context

The construction of a dam always represents a major change in the enviroments related to the once free flowing river. The suspended sediments that are transported by the river settle upstream of the dam due to the low flow velocities regime governing these water bodys. The deposition of fine sediments causes loss in the storage volume of the reservoir. The fine cohesive sediments also have the property to absorb contaminats, acting as a source of pollutants, which can be relased into the reservoir (see Fig.1).

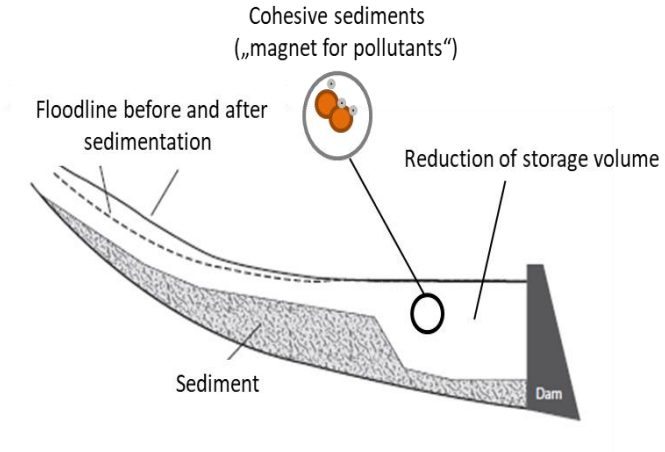

Figure 1. Issues caused by sedimentation affecting the management of reservoirs (adapted after: Annandale et al. 2016)

In frame of the project MuDaK-WRM three dimensional numerical models were set up for a Brazilian reservoir. It constitutes an useful tool to help water and sanitary companies to make decisions regarding the sediment management in the reservoirs. Such models are calibrated and validated using data from field measurements e.g. the sedimentation rates and deposition patterns (See Fig 2).

Objectives/Goals

- ✓ Sedimentation rate for the reservoir under specified boundary conditions (cm/year)
- ✓ Spatial distribution of deposited sediments

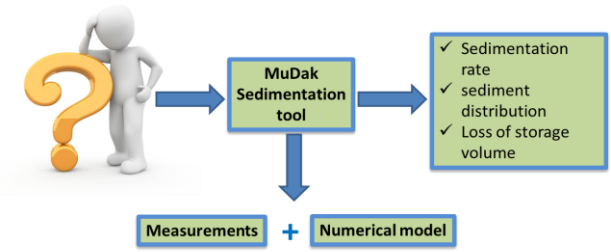

Figure 2. Schema of the sedimentation tool offered by MuDak WRM

Methods

The software Delft3D (Deltares, 2016)[1] was implemented for the numerical simulations within the present work. For the simulation of sediment transport in the Passaúna reservoir a curvilinear grid with 10 Sigma- layers (in total 28980 grid cells) was used. A total of 65 tributaries to the Passaúna reservoir are included in the model. For the modeled scenarios a simulation period of 17 months was defined (October 2017 – February 2019).

Several rating curves were used as the temporal distribution of the quantities of incoming sediments in function of the discharge at the inflows. Two sediment fractions(one cohesive, one non-cohesive) were defined for the simulation; this decision was based on data from sediment cores of the soil of the reservoir. The simulations were carried out taking into account the effects of wind.

Output of Delft3D

In the following some results for the reservoir are presented. Fig. 3. shows the simulated sedimentation rates and their spatial variations in the reservoir. This simulation was set up using a rating curve based on sediment loads calculated in frame of the project with MoRE (Modelling of Regionalized Emissions). The average incoming sediment concentration at the main inflow is 1600 mg/l for this rating curve.

The model simulated a sedimentation rate between 0 and 4.6 cm/year. According to the simulation a total volume of 70898 m³ of sediment was deposited in the reservoir during one year. Sauniti et al. 2002[2] meas-

1.Deltares,2016. Delft3D Flow: Simulation of multi-dimensional hydrodynamic flows and transport phenomena, including sediments.

2. SAUNITI, R. M.; FERNANDES, L. A.; BITTECOURT, A. V. L. Estudo do assoreamento dreservatório da barragem do rio Passaúna – Curitiba (PR). Boletim Paranaense de Geociências, v. 54,p. 65-82, 2004.

ured a sedimentation rate between 0.66 to 3.04 cm/year in the Passaúna reservoir. Within the frame of the MuDak-Project sedimentation rates between 0.1 and 6.0 cm/year were measured with a dynamic penetrometer. Also in frame of the project sediment traps were deployed into the water body. They showed decreasing sedimentation rates from the northern region of the reservoir to the dam. In the model the same tendency is found.

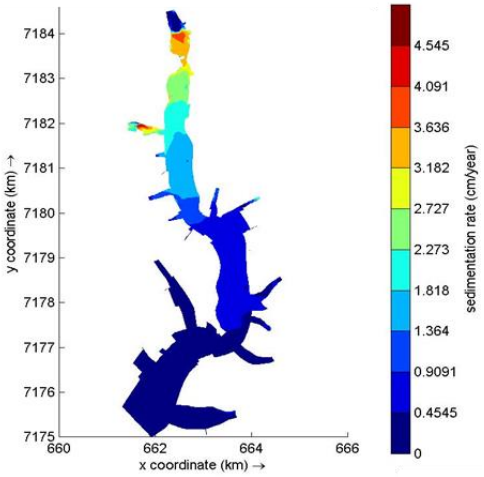

Figure 3. Simualted sedimentation rates for the Passaúna Reservoir using rating curve based on MoRE.

Fig. 4 shows the sedimentation rates simulated using a different rating curve. This rating cuve was based on data measured by the National Agency of Water (ANA) and AGUASPARANA. The average incoming sediment concentration at the main inflow is 70 mg/l. The resulting sedimentation rates vary between 0 and 0.25 cm/year.

In the Fig. 5 we can observe the simulated suspended sediment concentrations at the water surface for a specific date (14.02.2018) for both simulations.

Discussion

As can be appreciated in the presented results, the rating curve to be employed for the model is extremely important. Since depending on these input parameter the sedimentation rates, its spatial distribution and also the suspended sediment concentrations will vary.

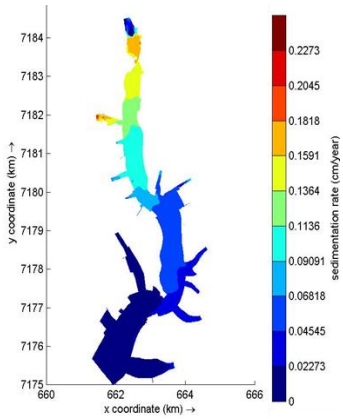

Figure 4. Simulated sedimentation rates for the Passaúna Reservoir using rating curve based on Data of the ANA and AGUASPARANA.

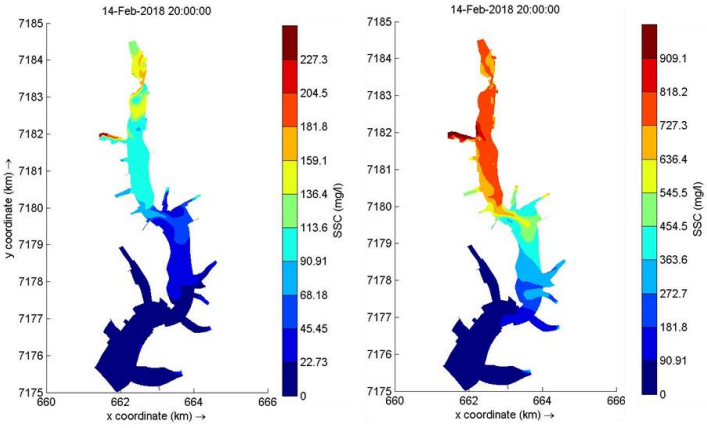

Figure 5. Simulated suspended solid concentrations at the water surface for both simulations. Left: using rating curve based on measurement of ANA and AGUASSANEPAR. Right : using rating curve based on MoRE.

Innovation/Outlook

- ✓ The numerical model can be used to simulate the system response of the reservoir to different scenarios and boundary conditions. where the input parameters are changing.
- ✓ Simulation of deposition patterns and deposition rates for reservoir management
- ✓ Simulation of suspended sediment concentrations.

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